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Verification Statement

I verify that the attached document represents a complete and accurate translation in English of the German original of the published international patent application PCT/EP03/02575- PCT document WO 03/078292 A1 entitled "Optical device for the automatic loading and unloading of containers onto vehicles"- as it was filed (and published). I certify that I am a professional translator who is fluent in the English and German languages.

Ron Radzai/ Ashland, PA, U.S.A. — 16 AUG 2004
Date

Sworn true and correct this 16th day of August 2004

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Optical device for the automatic loading and unloading of containers onto vehicles

Specification

The invention pertains to a method for reloading in a container storage space for standard containers, with a stacker crane for the containers that services the container storage space and can be controlled by a DP system for logistical management, which can travel between the storage location of each container and a loading platform of a container transport vehicle that can drive into the region of the container storage space, wherein the stacker crane has a means of picking up the container from the loading platform and/or setting it down onto the platform, such as can be oriented with respect to the latter.

Container storage yards are required for short-term interim storage of standard containers, in order to enable the transfer of containers from one means of transport to another. Means of container transport are generally large container ships, railroad cars, trucks, trailers, or also AGVs (automated guided vehicles). At a container harbor, container ships are unloaded and the unloaded containers are temporarily kept in the container yard until further transport is possible. Vice versa, the containers are assembled and kept temporarily in a container yard of a harbor in order to be loaded subsequently onto a container ship. The land transport occurs by truck, trailer, railroad car or AGV, and in the present application the land transport is furnished by special trucks.

The large number of containers handled at a container yard requires fast and accurate loading and unloading of the means of transportation. A stacker crane transports the container from the container yard to the transport vehicle and vice versa. The stacker crane can be an automatic container stacker crane (ACS), or also a gantry crane or a one-legged gantry crane. Thus far, the placement of the container onto a means of transport by the stacker crane has been manually controlled. The stacker crane consists of a bridge and a trolley which can travel on it, while the bridge can travel on rails. The placing of the container suspended from the crane onto a transport vehicle is manually controlled by an operator. For the loading, an operator present in the parking position drives the container by means of the stacker crane into the vicinity of the transport vehicle, and then by slow "approach" he positions the container exactly on the transport vehicle. The approach involves repeated left/right and forward/backward moving of the ACS, as well as the lowering of the container, controlled and monitored by the operator on site. Likewise, when unloading the transport vehicle, the stacker crane is slowly brought up to the container manually by an operator, so that the crane can pick it up.

The large number of containers handled within a container yard necessitates a smooth, error-free, speedy, economical and long-lasting work process. In addition, it is desirable to increase the throughput of containers, i.e., the number of containers handled per unit of time. This will reduce the parking time for containers inside the container yard, the layover time for container ships, and the stopping time for the land transport vehicles. At the same time, this implies a shortening of the length of transport for the containers.

The underlying problem of the invention is to achieve a high throughput of containers within a container yard, to lower the costs and to reduce the down time in case of defects, while at the same time boosting the economy of the container handling yard.

This problem is solved according to the invention by the indicated method for loading of transport vehicles with standard containers per claim 1, by the indicated method for unloading of transport vehicles with standard containers per claim 2, and by the indicated methods for adjusting the position of a stacker crane according to claims 17 and 19.

One benefit of the invention is the quick and flawless handling of the loading and unloading process of transport vehicles, made possible by automation. In the present application, the constantly recurring identical loading and unloading sequences are broken down into work steps and each of them is automated. The sequence of individual automated work steps with no interruption in time, such as require a shorter time to accomplish than the manual steps, and the mistake-free processing achieve a beneficial shortening of the time of the loading and unloading process and thus also boost the throughput of the containers handled.

The loading of a transport vehicle with a container occurs by the stepwise working of steps a) through f) of claim 1. Carrying out the work steps results in a shortening of the loading time of transport vehicles for standard containers, resulting in boosted throughput of the container handling yard. The resulting profitable time savings of the loading process comes from the individual savings accomplished by automating the work steps. At the same time, the number of mistake situations is reduced, which likewise has profitable impact on the throughput.

It is advantageous that the transport vehicle is identified and the thus-generated data are transmitted to the DP system of the logistical management. At the same time, the DP system of the logistical management generates a loading order for the stacker crane. This loading order contains the job for the stacker crane to pick up the container being loaded in the container yard and put it down on the loading platform of the transport vehicle, so as to load the transport vehicle in this way. The time advantage created by having

parallel work steps contributes to shorten the duration of the loading process, as does the fewer mistakes when detecting and transmitting the vehicle data.

Furthermore, it is beneficial that identification points defined by means of a calibrated camera system on the loading platform of the transport vehicle and their coordinates are transmitted to the DP system of the logistical management. From the identification points, the DP system determines the coordinates of the means of fastening of the transport vehicle (the corresponding system of coordinates describes at least a space reached by the fastening means of the load suspension device of the stacker crane). This method enables a quick and error-free detection of the position of the fastening means for the container, contributing to reduce the loading time for a transport vehicle.

It is especially advantageous for the DP system of the logistical management to compare the coordinates of the identification points with data about the container being loaded, which is stored in the DP system, and determine the fastening means being assigned to this container and the position coordinates on the loading platform of the transport vehicle. The coordinates stored in the DP system as to the size of the container can be compared in good time with the coordinates determined for the fastening means of the transport vehicle. If the size of the loading platform of the transport vehicle is sufficient for the container being loaded, the fastening means of the transport vehicle to be assigned will be determined. In the event that the loading platform of the transport vehicle is not large enough for the container being loaded, a premature termination of the loading process/loading order can occur, or the time-intensive picking up of the container from the container yard by the stacker crane can be prevented in good time, which represents a considerable time savings.

After the successful detecting of the coordinates of the fastening means, the loading process can begin at once for the transport vehicle located in the parking position. For this, the stacker crane travels under computer control with the container being loaded above the loading platform of the transport vehicle, overlapping it exactly, and above the position coordinates. The immediate and exact positioning of the stacker crane above the transport vehicle reduces the duration of the loading process thanks to elimination of the manual "approach".

The fastening means of the loading platform are detected by means of a calibrated camera system mounted on the stacker crane, and the container is moved so that the fastening means of the container stands congruently above the assigned fastening means of the loading platform. This enables a rapid, error-free, and correct orientation of the container with respect to the loading platform. In contrast with the previous method, the time-intense "approach" of the container by an operator present in the parking position is eliminated. It is advantageous that the visual monitoring can thus occur from a remote operator, who

watches the picture of at least one camera. Likewise, the uninterrupted sequence of the individual process steps helps reduce the loading time.

Thanks to the exact orientation of the container with respect to the loading platform, the container can be put down on the loading platform of the transport vehicle in such a way that the fastening means of the container mate with the corresponding fastening means of the loading platform at the end of the lowering process. The disadvantageous "approach" of the load suspension device with the container, guided by an operator present on site, is eliminated and thus produces a beneficial time savings. The container is deposited by the load suspension device on the transport vehicle and released. The loading job of the stacker crane is finished.

It is especially profitable that an operator does not have to be on site before, during and after the loading process. Thus, an operator is available for other activities.

It is especially advantageous that the transport vehicle is identified by means of a camera system. By elimination of visual and manual identification, the resulting data are transmitted faster and free of error to the DP system of the logistical management.

For detection of the coordinates of the identification points of the loading platform, an operator supported by a user-defined interface on a monitor screen of the DP system of the logistical management uses a marking mechanism to select the identification points of the loading platform on the user-defined interface. The user-defined interface shows the image of the camera system. An operator who selects the identification points of the loading platform of the transport vehicle represented on the user-defined interface with the marking mechanism, contributes to the error-free detection and quick calculation of the coordinates of the fastening means of the loading platform of the transport vehicle.

Another automation which reduces the loading time can be accomplished in that the coordinates of the identification points of the loading platform are automatically detected by a computer system and transmitted to the logistical management.

The process step described in claim 1 for determination of the position coordinates can be implemented in two different ways. First, it is advantageous to detect the coordinates of the loading platform of the transport vehicle in the loading and unloading zone. At this time, the transport vehicle is already identified and the assigned container is likewise known by virtue of the loading order. This allows the DP system of the logistical management to recognize early on whether the transport vehicle is suitable to accommodate the container being loaded. If the fastening means of the loading platform of a transport vehicle are

successfully assigned, the loading process will continue; otherwise, the loading process, if already started, will be interrupted.

In the event that the detection of the coordinates of the loading platform of the transport vehicle occurs in the final loading and unloading zone, the position coordinates described by the vertical position of the loading platform, and by the intersection of the diagonals of the identification points of the loading platform, are the absolute target position of the container. The arrangement is thus extremely adroit and enables a quick and thus time-saving positioning of the automatic stacker crane with the container above the loading platform being loaded.

Equally advantageous is the other embodiment of the invention of the process step described in claim 1 for determining the position coordinates. The detection of the coordinates of the loading platform of the transport vehicle in this case occurs in the identification zone. This allows the DP system of the logistical management to recognize early on whether the transport vehicle is suitable to accommodate the container being loaded. Once the fastening means of the loading platform of the transport vehicle are successfully assigned, the loading process will continue; otherwise, the loading process, if already started, will be interrupted.

Since the detection of the coordinates of the loading platform of the transport vehicle occurs in the identification zone, the coordinates detected for the loading platform refer to the transport vehicle. Thus, the vertical position of the loading platform and the intersection of the diagonals of the identification points of the loading platform describe the relative target position of the container.

The coordinates of the loading platform that are detected in the identification zone refer to the transport vehicle and consequently describe the relative target position of the container. Advantageously, the position coordinate is described by the absolute target position of the container, which is composed of the coordinates determined by means of a camera for the transport vehicle located in the parking position and the relative target position of the container. The coordinates already detected [in the] identification zone are linked to the position of the transport vehicle identified in the parking position by the DP system of the logistical management. The result of this linkage is the position coordinate, which is the absolute target position of the container. This enables an adroit and thus time-saving positioning of the automatic stacker crane with the container above the loading platform being loaded, as is described hereafter.

Regardless of where the detection of the coordinates occurs, a wrong position of one or more fastening means will be evident on the user-defined interface of the DP system. The operator recognizes the wrong positions and consequently notifies the driver of the transport means. He will correct any wrong positions of the fastening means in good time.

Regardless of the way chosen to detect the coordinates, the advantageous choice of the position coordinate will enable the load suspension device to move the container into the range of the loading platform, so that the intersection of the diagonals of the fastening means of the container stands congruent and plumb above the intersection of the diagonals of the fastening means of the loading platform. The container hanging from the stacker crane is thus situated in the middle above the loading platform and must consequently be oriented in the possibly next work step by a rotary movement of the container hanging from the load suspension device. For this, the stacker crane need not travel any further, i.e., the bridge of an ACS and the trolley moving on it have already reached their exact final loading position. In advantageous manner, the stepwise approach of the load suspension device, guided by an operator, is eliminated. This procedure enormously simplifies the positioning of the load suspension device and thus contributes to an extremely large reduction in the required loading time.

The simple watching of the loading process by an operator is granted by a second user-defined interface with four quadrants, each of them representing a pair of fastening means, while each pair consists of a fastening means of the loading platform, projected by an image from the camera system, and the associated fastening means of the container, projected by a superimposing of a computer-calculated contour of the container and of the fastening means onto the image. Thus, the operator comfortably watches the loading process, without having to be present at the parking position.

It is an exceptional benefit of the present invention that any deviation between the position of the container being loaded and the position of the loading platform can be determined in the DP system of the logistical management for a fine-tuned positioning, in that the second user-defined interface of the logistical management has a marking mechanism with which the operator selects at least one identification point of the loading platform. The thus-determined exact orientation of the loading platform is needed to orient the container with respect to the loading platform. A deviation of the orientations recognized by the DP system of the logistical management results, during the next step of the work sequence, in a correcting of the position of the container. The simple detecting of the position of the loading platform, the direct availability of the data in the DP system of the logistical management, and the excluding of errors from the data result in an exceptional time savings.

Just as advantageous is the configuring of the invention so that any deviation in position of the container being loaded with respect to the position of the loading platform is automatically recognized by a computer system for fine positioning.

When a deviation exists in the position of the container being loaded with respect to the position of the loading platform, the container is turned so that the fastening means of the container stand congruently and

plumb above the fastening means of the loading platform. Such a fast and correct orienting of the container with respect to the loading platform occurs automatically, based on the computed deviation. It is unusually advantageous that a tilting of the transport vehicle in its lengthwise and/or transverse direction, caused for example by uneven ground, does not have harmful impact on the loading process. The stepwise approach of the load suspension device with the container relative to the loading platform is eliminated, which produces an exceptional reduction in the time required for the loading of a transport vehicle.

The swift setting down and releasing of the container from the load suspension device is guided by an operator or automatically by a computer system. Since the container is exactly located above the loading platform and is correctly oriented, and the DP system has determined the vertical position of the loading platform, an immediate and continuous motion for depositing the container can be carried out, and it can be concluded sooner than the manual "approach". The locking together of the fastening means of the container and those in the loading platform completes the deposit of the container. After the load suspension device is no longer loaded with the container, which is indicated by the triggering of pressure sensors, the container can be released from the load suspension device and fastened to the transport vehicle.

The unloading of the transport vehicle loaded with a container is described by the sequential working of steps a) through f) of claim 2. The carrying out of the work steps produces a shortening of the unloading time of transport vehicles for standard containers, leading to an increased throughput of the container handling yard. The resulting profitable time savings of the unloading process consists of the individual savings achieved by automating the work steps. At the same time, the number of mistake situations is reduced, which likewise has profitable impact on the throughput.

It is advantageous that the transport vehicle and the container being unloaded are identified and the thus-generated data are transmitted to the DP system of the logistical management. At the same time, the DP system of the logistical management generates an unloading order for the stacker crane. This unloading order contains the job for the stacker crane to pick up the container being unloaded from the transport vehicle and store it in the container yard. The time advantage created by having parallel work steps contributes to shorten the duration of the loading process, as does the fewer mistakes when detecting and transmitting the vehicle data.

Furthermore, it is beneficial that identification points defined by means of a calibrated camera system on the container and their coordinates are transmitted to the DP system of the logistical management. From the identification points, the DP system determines the coordinates of the means of fastening of the container being unloaded (the corresponding system of coordinates describes at least a space reached by the fastening means of the load suspension device of the stacker crane). This method enables a quick and error-free

detection of the position of the fastening means of a container and thus contributes to reduce the unloading time for a transport vehicle.

It is especially advantageous for the DP system of the logistical management to determine the fastening means and position coordinates of the container from the identification points. This enables a quick and error-free calculation of the position coordinates, for the immediate starting of the unloading order for the transport vehicle.

For this, the stacker crane travels under computer control above the container, overlapping it exactly, and above the position coordinates. The immediate and exact positioning of the load suspension device above the container being unloaded reduces the time of the unloading process by eliminating the manual "approach".

The fastening means of the container are detected by means of a calibrated camera system mounted on the stacker crane, and the load suspension device is moved so that the fastening means of the container or of the load suspension device stands congruently above the assigned fastening means of the container. This enables a rapid, error-free, and correct orientation of the load suspension device with respect to the container. In contrast with the previous method, the time-intense "approach" of the load suspension device by an operator present in the parking position is eliminated. It is advantageous that the visual monitoring can thus occur from a remote operator, who watches the picture of at least one camera. Likewise, the uninterrupted sequence of the individual process steps helps reduce the loading time.

Thanks to the fast and exact orienting of the fastening means of the load suspension device with respect to the container, the load suspension device can be brought up to the container in such a way that the fastening means of the load suspension device mate with the fastening means of the container. The disadvantageous "approaching" of the load suspension device to the container, guided by an operator, is eliminated and thus produces an advantageous time savings. The container is removed from the transport vehicle and can be unloaded by the load suspension device, which then stores it temporarily in the container yard. The unloading job of the stacker crane is thus finished.

It is especially profitable that an operator does not have to be on site before, during and after the unloading process. Thus, an operator is available for other activities.

It is especially advantageous that the transport vehicle and the container being unloaded is identified by means of a camera system. By elimination of visual and manual identification, the resulting data are transmitted faster and free of error to the DP system of the logistical management.

For detection of the coordinates of the identification points of the container, an operator supported by a user-defined interface on a monitor screen of the DP system of the logistical management uses a marking mechanism to select the identification points of the container on the user-defined interface. The user-defined interface shows the image of the camera system. An operator, who selects the identification points of the container represented on the user-defined interface with the marking mechanism, contributes to the error-free detection and quick calculation of the coordinates of the fastening means of the loading platform of the transport vehicle.

Another automation which reduces the unloading time can be accomplished in that the coordinates of the identification points of the container are automatically detected by a computer system and transmitted to the logistical management.

The process step described in claim 2 for determination of the position coordinates can be implemented in two different ways. First, it is advantageous to detect the coordinates of the container in the loading and unloading zone. The position coordinate, which is described by the vertical position of the upper edge of the identification points of the container and by the point of intersection of the diagonals of the identification points of the loading platform, [is?] the absolute target position of the container. The arrangement is thus extremely adroit and enables a quick and thus time-saving positioning of the automatic stacker crane with the load fastening means above the container being unloaded.

Equally advantageous is the other embodiment of the invention of the process step described in claim 2 for determining the position coordinates. The detection of the coordinates [of the] container in this case occurs in the identification zone. The position coordinate is described by the vertical position of the upper edge of the identification points of the container and by the intersection of the diagonals of the identification points of the container, which describes the relative target position of the container. By selecting the upper edge of the identification points (fastening means) of the container as an element of the position coordinate, one can also unload standard containers not having a cover, such as open-top containers, tank containers and/or flat containers. Thus, the favorable choice of the position coordinate enables an adroit and thus time-saving positioning of the automatic stacker crane above the container being unloaded, which shall be described hereafter.

The coordinates of the container that are detected in the identification zone refer to the transport vehicle and consequently describe the relative target position of the load suspension device. Advantageously, the position coordinate is described by the absolute target position of the load suspension device, which is composed of the coordinates determined by means of a camera for the transport vehicle located in the parking position and the relative target position of the load suspension device. The coordinates already detected [in the] identification zone are linked to the position of the transport vehicle identified in the

parking position by the DP system of the logistical management. The result of this linkage is the position coordinate, which is the absolute target position of the load suspension device. This enables an adroit and thus time-saving positioning of the automatic stacker crane above the container being unloaded, as is described hereafter.

Regardless of the way chosen to detect the coordinates, the advantageous choice of the position coordinate will enable the load suspension device to be moved into the range of the container, so that the intersection of the diagonals of the fastening means of the load suspension device stands plumb above the intersection of the diagonals of the fastening means of the container. Thus, the load suspension device crane is situated in the middle above the container and must consequently be oriented in the possibly next work step by a rotary movement of the load suspension device. For this, the stacker crane need not travel any further, i.e., the bridge of an ACS and the trolley moving on it have already reached their exact final unloading position. In advantageous manner, the stepwise approach of the load suspension device, guided by an operator, is eliminated. This procedure enormously simplifies the positioning of the stacker crane and thus contributes to an extremely large reduction in the required unloading time.

The simple watching of the unloading process by an operator is granted by a second user-defined interface with four quadrants, each of them representing a pair of fastening means, while each pair consists of a fastening means of the container, projected by an image from the camera system, which is situated on the load suspension device, and of the associated fastening means of the load suspension device, projected by a superimposing of a computer-calculated contour of the load suspension device and of its fastening means onto the image. Thus, the operator comfortably watches the unloading process, without having to be present at the parking position.

It is an exceptional benefit of the present invention that any deviation between the position of the load suspension device and the position of the container being unloaded can be determined in the DP system of the logistical management for a fine-tuned positioning, in that the second user-defined interface of the logistical management has a marking mechanism with which the operator selects at least one identification point of the container. The thus-determined exact orientation of the container is needed to orient the load suspension device. A deviation of the orientations recognized by the DP system of the logistical management results, during the next step of the work sequence, in a correcting of the position of the fastening means of the load suspension device. The simple detecting of the position of the container, the direct availability of the data in the DP system of the logistical management, and the reducing of errors in the data result in an exceptional time savings.

Just as advantageous is the configuring of the invention so that any deviation in position of the load suspension device with respect to the position of the container being unloaded is automatically recognized by a computer system for fine positioning.

When a deviation exists in the position of the load suspension device with respect to the container being unloaded, the load suspension device is turned so that the fastening means of the load suspension device stand congruently and plumb above the fastening means of the container. Such a fast and correct orienting of the load suspension device with respect to the container occurs automatically, based on the computed deviation. The stepwise approach of the load suspension device relative to the container is eliminated, which produces an exceptional reduction in the time required for the unloading of a transport vehicle.

The swift and continuous approach of the load suspension device to pick up the container and the locking together of the fastening means is guided by an operator or automatically by a computer system. Since the load suspension device is exactly located above the container and is correctly oriented, and the DP system has determined the vertical position of the container, an immediate and continuous motion for depositing the load suspension device can be carried out, and it can be concluded sooner than the manual "approach". The locking together of the fastening means of the load suspension device and those in the container completes the picking up of the container. The container is fastened to the load suspension device and the stacker crane places it in the container yard for temporary storage. Thus, the unloading job order is complete.

The continuous sequence of process steps enables a fast loading and unloading of a transport vehicle. The time saved in this way is available for other loading or unloading processes. Consequently, the throughput of containers handled in a container yard can be increased, which represents an efficiency boosting and likewise a reduction in the transport time of the transported freight.

Furthermore, it is advantageous that an adjustment of a stacker crane is possible at any time and with little expense by using the method described in claim 17. It should be kept in mind that geometrical deviations in a camera provided for use on the stacker crane can be produced by structural part tolerances, manufacturing tolerances, irregularities in the lens and/or optical errors, and can be circumvented by a calibration done prior to use of the camera. During operations, the image from a camera used on the stacker crane is continuously corrected by means of a correction algorithm obtained from the calibration. Thus, the correction algorithm specific to the camera is applied to each image of a camera by the DP system of the logistical management. Consequently, each camera used has identical optical properties if its corresponding correction algorithm is applied. In addition, the preliminary calibration allows the DP system of the logistical management to remotely measure the familiar objects being viewed, in accordance with the laws of optics.

By using this calibrated camera, a further adjustment of the position of the stacker crane can now be carried out. Per claim 17, the stacker crane first moves over a reference point situated at any given position within the container yard, so that at least one camera of the camera system catches the reference point. The DP system of the logistical management compares the new position of the reference point, calculated from the camera image, with its known position of the reference point and, if any deviation is present, it determines an offset for the stacker crane. Under the assumption that the reference point in general does not shift, a correction can be made in the position coordinate of the stacker crane by the DP system of the logistical management, adding the offset to the calculated position data of the stacker crane. This is especially profitable in the case of a length change in the running rails of the automatic container stacker (ACS) crane, which is an expansion of length in summer and a contraction of the running rails in winter due to the temperature. Since the DP system of the logistical management determines the position in terms of an absolute length measurement of the distance traveled by the stacker crane, the temperature-sensitive arrangements and positions that the stacker crane actually travels can be displaced from the position calculated by the DP system of the logistical management. Thus, in advantageous manner, it is possible to correct an erroneous calculation of the position of the stacker crane caused by these factors of influence. What is especially advantageous in this case is that the stacker crane can be quickly adjusted as often as desired and at any given time.

It is especially advantageous to arrange several reference points within the container yard. After the stacker crane has placed itself above one of these reference points, the DP system of the logistical management can compare the position of the reference point already known to it with the new position calculated from a camera image, and calculate any offset for the stacker crane associated with the reference point. In the event that several reference points are located along the linear path of the stacker crane and one of the offsets of these reference points determined in a narrow time domain has a nonsystematic deviation, this indicates ground shifting in the vicinity of the affected reference point, which is afterwards introduced into the calculations for positioning of the stacker crane by the DP system of the logistical management as a correction. In this way, one can avoid any wrong interpretations of length expansions.

It is especially advantageous for the container yard to have a super-reference point, with which each camera on the stacker crane can be adjusted relative to it. Replacing a camera mounted on the stacker crane due to a technical defect, etc., requires the onetime adjustment of a newly installed camera on the stacker crane. By using the super-reference point, the DP system of the logistical management can determine a correction vector and assign it to a new camera mounted on the stacker crane. The repair and adjustment time and thus the down time of the stacker crane is profitably shortened. The super-reference point is advantageously situated at one position in the container yard that is independent of outside influences of the above described kind. The stacker crane travels with the newly installed and already calibrated camera above the

super-reference point so that the newly installed camera detects it. The DP system determines the position of the super-reference point and compares the data thus obtained with the already stored data about the super-reference point. If there is any deviation in the data, a correction vector will be assigned to the newly installed camera, and it will be used during each position computation done on the basis of this camera. The timesaving achieved due to the swift adjustment of the newly installed camera on the stacker crane can be used profitably for loading and unloading processes.

Description of figures:

Figure 1	overview of a container handling yard,
Figure 2	identification zone for detection of transport vehicles,
Figure 3	section of a container handling yard, container storage space and parking position,
Figure 4	side view of the area shown in figure 3,
Figure 5	representation of the viewing angle of the camera placed in the parking position,
Figure 6	first user-defined interface,
Figure 7	representation of the viewing angle of the camera arranged on the side of the automatic container crane,
Figure 8	representation of the viewing angle of the camera arranged on the side of the automatic container crane,
Figure 9	second user-defined interface, during a loading process,
Figure 10	user-defined interface at the end of a loading process,
Figure 11	another embodiment of an identification point,
Figure 12	another section of a container handling yard, container storage space and parking position,
Figure 13	another representation of the viewing angle of the camera arranged in the parking position,
Figure 14	representation of the arrangement of a reference point.

Figure 1 shows an automated container terminal 24 for containers 1, where trucks 7 (figure 2) are loaded and unloaded at the land side. In an identification zone 25, arriving and departing trucks 7 are identified and/or surveyed. An arriving truck 7 is identified and the data thus generated, which are required for the loading and unloading, are transmitted to the DP system (not shown) for logistical management. After this, the truck 7 moves to the loading or unloading zone 6 by roadways 26.

Figure 2 shows the cameras 27 arranged in the identification zone 25, which are used to detect the truck 7 from all sides. The license number 28 of the truck 7 and possibly the license number 29 of the trailer 7.1 are automatically detected by the cameras 27. Likewise, the identification number 30 of the container 1 will also be detected in the case of loaded trucks 7. All information regarding the truck 7, the trailer 7.1, and possibly the container 1 will be transmitted to the DP system of the logical management and be available in the system at all times and can be called up by an operator (not shown).

In the automatic container storage space 2, as depicted in figure 3 and 4, the containers 1 are kept in stacks. The automatic stacker crane 3 consists of a mobile trolley 3.2, which can travel on a bridge 3.1, while the bridge 3.1 can travel on the crane track 4. During the loading process, the container 1 is rigidly connected to the moveable mast 3.3 of the moveable trolley 3.2. On the mast 3.3 is situated the load suspension device 3.4 of the stacker crane 3, which accommodates the container. The automatic stacker crane 3 is coupled to the DP system of the logistical management and can thus reach every possible coordinate within the travel zone at any time. The coordinate system (not shown) describes a space which is reached by the load suspension device 3.4 of the automatic traveling stacker crane 3. In place of an ACS, one can also use gantry cranes or one-legged gantry cranes.

The automatic container storage space 2 is bounded off from the loading and unloading zone 6 by a border 5, which can be a fence or a wall. In the loading and unloading zone 6, the trucks 7 are each positioned in a parking position 8. Figures 3 and 4 show trucks 7 that have been backed into a parking position 8, which was assigned to them. The parking positions 8 have concrete gutters 8.1 at the sides, which facilitate the backing in of the trucks 7 when parking, since the wheels 9 of the truck 7 are guided in this way. The parking process is completed when the truck 7 backs up and its wheels 9 strike against the cross struts 8.2 bounding the parking position 8.

Each parking position 8 is outfitted with a fixed and calibrated camera system 10, which is located above the boundary 5 (figure 5). The viewing angle 11 of the camera 10 is chosen so that all loading platforms 31 of the truck 7 and any containers 1 located thereupon are completely detected. Thanks to this viewing angle 11 of the camera 10, an operator at a monitor 12 (figure 6) can observe the parking process.

Figure 6 shows the monitor 12 with the image of the camera 10, by which the operator can observe and control the parking process of the truck 7 and the loading and unloading process. For the loading of the truck 7 in the parking position 8, the position of the loading platform 31 of the truck 7 has to be measured. For this, a marking mechanism such as a crosshair 14 is superimposed on the image of the camera 10, with which the operator can select identification points. These identification points are the fastening means of the loading platform 31 of the truck 7, the so-called twistlocks 13. The coordinates of the twistlocks 13 are transmitted to the DP system of the logistical management in order to calculate the position coordinate of the loading platform 31. The DP system of the logistical management calculates the diagonals 16 of the twistlocks 13 and their point of intersection 17. The intersection 17 describes the vertical position 15 of the loading platform in the system of coordinates. This computation is made possible by a previous calibration of the fixed installed camera 10, whose exact position and viewing direction is known.

The container 1 located on the rigid mast 3.3 of the stacker crane 3, as depicted in figure 7, is positioned above the loading platform 31 of the truck 7 so that the point of intersection of the diagonals of the fastening means of the container 1 stands congruently and plumb above the point of intersection 17 of the diagonals 16 of the fastening means of the loading platform 31 of the truck 7. Thanks to the cameras 18 arranged on the stacker crane 3 and thanks to the chosen type of positioning of the container 1 being loaded above the loading platform 31, the viewing angle 19 of the camera 18 can be restricted, as depicted in figure 8. Due to the different container sizes of 20 ft., 30 ft., 40 ft. to 45 ft., two viewing angles 19.1 and 19.2 are required left and right, disregarding the middle zone of the container 1. In terms of the coordinates of the point of intersection 17 of the diagonals 16 of the loading platform 31, a viewing range of the camera system 42.1 from –7m to –3m and a viewing range of the camera system 42.2 from +3m to +7m is necessary. Only in these areas are there twistlocks 13 of the loading platform 31 adapted to the container 1.

Figure 9 shows the four-part user-defined interface 20 of the DP system of the logistical management. Each quadrant shows one image segment, which is generated by at least one of the cameras 18 arranged on the side of the stacker crane 3. For redundancy reasons and reliability considerations, the four image segments can be generated from the image of a camera, or also from two images of two cameras arranged at the side. It is likewise possible to implement a solution that provides one camera for each image segment. Each image segment shows the fastening means, the twistlocks 13 of the loading platform 31. The operator can recognize a wrong position for the twistlocks 22 and then use an intercom system to ask the driver of the truck 7 to correct this wrong position. The computer-calculated contours of the container 23 are superimposed on the image, showing the operator the actual position of the container 1. The orientation of the container 1 with respect to the loading platform 31 is accomplished by the operator using a marking mechanism, such as a crosshair 24 [sic], to once again select the fastening means or twistlocks 13 of the loading platform 31. The coordinates of the fastening means of the loading platform 31 are once again transmitted to the DP system of the logistical management. The actual orientation of the loading platform 31 is calculated from this. Any deviation between the orientation of the container 1 and the orientation of the loading platform 31 is determined by the DP system of the logistical management and the container 1 is rotated on the mast 3.3 by means of the load suspension device 3.4 so that all fastening means of the container 1 stand congruently and plumb above the fastening means of the loading platform 31.

During the lowering process, the computer-calculated contour 23 of the container is newly calculated at any time and superimposed on the image frozen at the start of the lowering process, as represented in figure 10. At the end of the lowering process, the fastening means of the container 1 engage with the fastening means of the loading platform 31 of the truck 7. The operator watches and controls the loading process on the monitor as the container 1 is set down.

Another method for detecting the identification points of the loading platform 31 of a truck 7 or the identification points of a container 1 is shown by figures 11 to 13. The known process steps of the previously described process are rearranged here.

Figure 11 shows a modified identification zone 25, in which the arriving truck 7 including a possibly present container 1 is identified. The identification of the truck 7 involves the recognition of the license plate 28, 29 of the transport vehicles and the identification number 30 of the possibly present container 1 by means of the cameras 27 arranged at the identification zone 25, which are connected to the DP system of the logistical management and transmit the so-generated data to it. In addition to the work step described in figure 2, the possibly present container 1 and/or the empty loading platform 31 of the truck 7 are then measured. The truck 7 is detected from the side 32 and from above (top view) 33 by means of the camera 27. The detection of the identification points of the loading platform 31 (or container 1) as described in figure 6 does not occur in the loading and unloading zone 6, contrary to figure 6, but rather in the identification zone 25. The course of the detection of the identification points remains identical. At the same time, there is an automatic measuring of the height 34, 35 of the fastening means being used by the camera 27. The coordinates found are transmitted to the DP system, and these represent the relative target position of the container being unloaded, since they pertain only to the truck 7. The driver of the truck 7, after a successful identification and measurement of the truck 7, receives an access authorization in the form of a magnetic card or chip card (not shown). The magnetic card also contains all relevant data concerning the handling order.

The driver drives the truck 7 to a loading and unloading zone 6 assigned to him (figure 12) and backs his transport vehicle up into any desired parking position 8 within the loading and unloading zone 6. During the parking process, as represented in figure 13, an object recognition is started in the DP system of the logistical management by means of a camera 36 arranged in the parking position 8, which identifies the truck 7 and also classifies it geometrically in the system of coordinates, not represented. The information from the camera 36 arranged at the border 5 allows the DP system of the logistical management to exactly recognize the truck 7 in terms of its identity and position: its distance 37 from the border 5, a left/right offset within the parking position 8 and angle of twist of the truck 7 relative to the ground 38. Thus, after completing the parking process, the exact position of the truck 7 is known to the DP system of the logistical management. From these coordinates, and in conjunction with the relative target position of the container 1, the DP system of the logistical management can determine the position coordinate for the container 1 being loaded, which represents the absolute target coordinate for the container being loaded.

Next, the driver of the truck 7 goes to a reporting space 39, in order to signal with the magnetic card his readiness for loading or unloading of the truck 7. The DP system checks the data on the magnetic card against the data obtained from the parking position 8 of the truck and if they agree it, generates an order for

the stacker crane 3. The stacker crane 3 picks up the container 1 to be loaded from the container storage space 2 and begins the loading of the truck 7 in accordance with the method described as of figure 7.

Furthermore, figure 12 shows a tolerance range 40. Within each parking position 8, the load suspension device 3.4 of the stacker crane 3 can only travel within this special tolerance range 40, for safety reasons.

Figure 14 shows a container yard 2 with a reference point 41.

List of reference symbols

1	Container
2	Container yard
3	Automatic container stacker crane
3.1	Bridge
3.2	Trolley
3.3	Mast
3.4	Load suspension device
4	Crane track
5	Boundary
6	Loading and unloading zone
7	Truck
7.1	Trailer
8	Parking position
8.1	Concrete troughs
8.2	Cross braces
9	Wheels
10	Camera at the parking position
11	Viewing angle of camera 10
12	Monitor with picture of camera 10
13	Twistlocks
14	Cross hairs of the first user-defined interface
15	Vertical position of the parking position
16	Diagonals
17	Intersection of 16
18	Camera system mounted on the side of the ACS 3
19	Viewing angle of camera 18
19.1	Viewing angle of camera 18
19.2	Viewing angle of camera 18
20	Second user-defined interface with the pictures of cameras 18
22	Wrong positioning of a twistlock
23	Superimposed contour of the container 1
24	Automatic container terminal
25	Identification zone
26	Roads

27 Cameras for identification
28 License plate of truck 7
29 License plate of trailer 7.1
30 ID number of a container 1
31 Loading platform of the truck 7
32 Side of the truck 7
33 Top view of the truck 7
34 Height of the fastening means of the loading platform 31
35 Height of the fastening means of the container 1
36 Camera in the parking position 8 in the alternative version
37 Distance of truck 7 from the boundary 5
38 Ground
39 Dispatching room
40 Tolerance range
41 Reference point
42.1 Viewing range 1 of camera system 18
42.2 Viewing range 2 of camera system 18